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The British Army Air Corps In-Flight Spatial Disorientation Demonstration Sortie (Reprint)

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Following didactic instruction, most aircrew are able to experience some of the disorientating illusions and limitations of the orientational senses in a variety of ground-based devices. In order to reinforce instruction in spatial disorientation (SD) within the environment in which they operate, British Army Air Corps helicopter pilots also receive an airborne demonstration of the limitations of their orientation senses. Since 1982, a specific SD sortie has been programmed towards the end of the basic rotary-wing phase of flight training approximately 6 weeks after the aeromedical training module, and before students commence rotary-wing instrument flight training. Refresher sorties are flown every 4 years. The conduct of the SD sortie is described in detail. Analysis of helicopter accidents demonstrates that this training is operationally effective by contributing towards the reduction of SD-related mishaps. It is cost-effective and the addition of this type of in-flight demonstration to the aeromedical training syllabus is regarded as being of great value to British Army helicopter aircrew. Similar instruction could be readily adopted by other services.

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The British Army Air Corps In-Flight Spatial Disorientation Demonstration Sortie

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Following didactic instruction, most aircrew are able to experience some of the disorientating illusions and limitations of the orientational senses in a variety of ground-based devices. In order to reinforce instruction in spatial disorientation (SD) within the environment in which they operate, British Army Air Corps helicopter pilots also receive an airborne demonstration of the limitations of their orientation senses. Since 1982, a specific SD sortie has been programmed towards the end of the basic rotary-wing phase of flight training approximately 6 weeks after the aeromedical training module, and before students commence rotary-wing instrument flight training. Refresher sorties are flown every 4 years. The conduct of the SD sortie is described in detail. Analysis of helicopter accidents demonstrates that this training is operationally effective by contributing towards the reduction of SD-related mishaps. It is cost-effective and the addition of this type of in-flight demonstration to the aeromedical training syllabus is regarded as being of great value to British Army helicopter aircrew. Similar instruction could be readily adopted by other services.

DEMONSTRATION OF SOME of the illusions of spatial disorientation (SD) and the limitations of the orientational senses during ground-based training is a vital part of the proper education of aviators. Most student pilots are given instruction during their flight training on how to overcome the effects of SD, but few air forces provide a specific SD demonstration sortie to reinforce the knowledge gained during ground-based training.

There is a distinct difference between in-flight demonstration of SD, and training to overcome the problem once it has occurred. A demonstration of SD consists of reinforcement of the limitations of the orientation senses in flight and the enhancement of aircrew awareness to potentially disorientating situations. SD training, on the other hand, consists of a series of flight procedures to cope with disorientating circumstances and illusions (e.g., recovery from unusual attitudes during instrument flying). SD training is clearly the responsibility of the flight instructor in both simulator and actual flying sorties, while the demonstration of physiological limitations is best conducted by the flight surgeon pilot who, having performed the ground-based training, is on-hand to explain the mechanics of SD.

A specific British Army spatial disorientation sortie was developed and has been conducted since 1982. Although the U.S. Air Force used to fly a similar sortie, no other nations or services are known to currently enhance the awareness of aircrew in their physiological limitations in this way.* The aim of the SD demonstration sortie is to reinforce, in a real environment, the ground training received in SD and consequently increase the awareness of trainee pilots. The objective has been to provide aircrew with an initial SD demonstration sortie and a refresher every 4 years. This has been achieved in the main since it has become a mandatory requirement of aircrew continuation training. This paper describes the conduct of the sortie and discusses the operational and cost benefits.

Description of the SD Demonstration Sortie

The sortie is flown by a pilot-physician (Flight Surgeon) in the Gazelle AH1 helicopter (SA 341). Three students can be flown on each sortie, one in the copilot's seat and two in the rear passenger seats. It can be completed in about 25 to 30 min flight time, so 12 students can receive the demonstration in 2 h. The sortie was originally adapted from those described in Benson (1) and has since been modified from the description provided by Edgington and Box (4).

Typically, students have had about 100 h basic fixed-wing and basic helicopter experience and will fly the sortie before they start rotary-wing instrument flight training. They will have completed the classroom aviation medicine and disorientation training a few weeks prior to the sortie.

General reassurance is given that no violent maneuvers will be flown, and that only one student will have his or her eyes shut at any one time for no more than

*Braithwaite MG. Towards standardization in spatial disorientation. Position paper to Working Party 61 of the Air Standardization Coordination Committee, September 1994.

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a minute or so. During each demonstration the subject student gives a running commentary of his/her perception of orientation with particular reference to pressure altitude, heading and airspeed. Primarily for flight safety reasons, the sortie is best flown in good visual meteorological conditions (VMC) but since it is difficult to completely prevent transmission of light to the eyes, bright sunlight is best avoided. In order to save time, the sortie is conducted close to the base airfield, but an area of low aviation activity is chosen for safety. The observing students are also instructed to assist with aircraft lookout.

During the transit to the exercise area, the use of the special senses in orientation is only briefly reviewed as initial students have received classroom instruction a few weeks prior to the sortie, and refresher students, a lecture on the same day as the sortie. The overwhelming contribution of vision to orientation is stressed together with the fact that SD is primarily a problem associated with poor external visual conditions, thus emphasizing why the students will be deprived of their vision during the exercises.

The specific maneuvers have been chosen on the basis that they are simple to perform, are easily repeatable and have operational relevance to the most commonly experienced types and degrees of SD. At the commencement of each maneuver, the subject student is told to sit free of the controls and airframe structures other than the seat, note the aircraft's initial flight parameters and then to close his or her eyes and give a running commentary as described above. The other students are asked to observe but not comment until after the maneuver. Each student experiences at least one exercise in each of the forward flight and hover groups.

Forward Flight

Exercise 1: Straight and level flight is established at 100 knots. After 10 s, a gently increasing (suprathreshold) roll to 30° angle of bank is commenced while maintaining airspeed and pressure altitude. This is stabilized and, on completion of a 360° turn, the aircraft is rolled wings level again at a suprathreshold rate. The onset of the roll is normally detected, but as the semicircular canal response decays, a false sensation of a return to straight and level flight is perceived. As the roll to level flight is made, a sensation of turning in the opposite direction is perceived. The student is told to open his or her eyes once he considers that he or she is again straight and level. The observing students are asked to tell the subject what actually happened and all are asked for their comments. The flight surgeon will then remind the students of the physiology of semicircular canal performance.

Exercise 2: Straight and level flight is established at 100 kn and one of the other students is asked to close his or her eyes. The aircraft is flown with no alteration of height, heading, or airspeed. Because of small aircraft movements from turbulence and the aerodynamic response of the helicopter which stimulate the kinaestheic and/or the vestibular apparatus above threshold, all students perceive climb, descents, or turns in unpredictable and varying amounts. The erroneous sensations produced by brief stimulation of the kinaestheic receptors and vestibular apparatus is discussed.

Exercise 3: Straight and level flight is established at 100 kn into wind, and once the subject has closed his or her eyes, the helicopter is slowed within 30–40 s to a free air hover with no change of heading or height. Both the deceleration and the nose-up pitch associated with the attitude change when slowing the aircraft convinces the student that a climb is taking place. In addition, a turn is often falsely perceived when balance variations are made to keep straight. The somatogravic illusion is discussed.

Exercise 4: This maneuver is best conducted from 500 ft above ground level. Straight and level flight is established at 100 kn and the student closes his or her eyes. A sub-threshold descending turn is commenced as gently as possible. Within 30 s in the Gazelle, it is possible to lose 500 ft in height and turn through 180°. The student, remembering the second demonstration, usually states that he is straight and level. When the aircraft is established in low level flight, the student is asked to report his or her heading and height and airspeed and then open his or her eyes. This demonstration forcibly and convincingly demonstrates a Type 1 orientation error, due to the proximity of the ground.

Hover

The helicopter has a unique ability to accelerate about as well as along orthogonal axes, thus the final series of demonstrations starts from a 5- or 6-ft hover. For this series of exercises, it is most important to check for hazards: the terrain surroundings should be familiar and a good lookout maintained during clearing turns between each exercise. In turn, the three students are exposed to a variety of linear and rotational movements while maintaining hover height. The flight surgeon keeps prompting the subject for a running commentary (to occupy channels of attention) and so exacerbate the onset of SD. Most aircrew are able to maintain their orientation for 10 to 15 s before losing it. Within these exercises it is possible to "hide" various maneuvers so that when the student opens his or her eyes, a dramatic end point is evident:

- a towering vertical climb to 200–300 ft
- climbing backwards at 10–15 kn
- landing without the student realizing it
- a gentle transition to forward flight

These exercises have a most educational effect upon the observing students and are discussed in the context of snow, sand, and night operations.

Additional Exercises

The exercises described above are the recommended minimum. Should time permit, and particularly for refresher training, variations of these exercises and additional ones can be performed:

- Straight and level flight is established at 100 kn, the eyes are closed, and the aircraft dived to a 20° nose down attitude. A steady pull up to 30° nose up is then made with a gentle bunt recovery. Most students perceive a continuing full loop; some experience a barrel roll sensation.
- The reverse of slowing down to a free air hover can be flown, i.e., from a slow speed to maximum cruise speed. Diving sensations are usually perceived.
- From a free-air hover into wind, the aircraft is pitched nose down to approximately 50°. This demonstration is visually stimulating to the observers but the angle of pitch down is generally "under-perceived" by the subject.
- In steep turns each student in turn is invited to perform rapid head movements in pitch or yaw to experience the Coriolis phenomenon.

Debriefing

On the return flight to the base airfield, the sortie is discussed with particular reference to the significance of sub-threshold maneuvers and erroneous sensory information cues. The students are reassured that they are all physiologically normal but just not "designed" for flight. It is stressed that the aim of the sortie has been to provide them with an idea of the limitations of their own physiology in the environment in which they operate and the phases of flight commonly associated with SD. Similarly, they must realize that they have not been trained to overcome the effects of SD. That is the responsibility of their flight instructors to address during later training in the recovery actions from unusual attitudes and procedures upon inadvertent entry into IMC. They are advised that the best that they can do individually with respect to SD, is to achieve and retain currency and competency at instrument flying.

Benefits of the Sortie

Operational Benefits

In order to estimate the benefit of this sortie on British Army Air Corps operations, the non-hostile SD flying accidents (i.e., excluding ground-handling mishaps) were compared between the periods before (1971–1982) (6), and since (1983–1993) (2) the introduction of the sortie. The SD accident rates were 2.04 accidents per 100,000 flying hours and 0.57 accidents per 100,000 flying hours, respectively. Using a Poisson regression analysis (5) the Likelihood Ratio in the Type 3 analysis revealed a significant difference between both the period [Chi square (df = 1) = 5.8563; p = 0.0155], and classification of accident [Chi square (df = 1) = 73.9731; p = 0.0001]. This was interpreted to demonstrate a period effect of a highly significant reduction in the SD accidents rates since the sortie has been introduced.

There are confounding factors in this analysis. Some factors will have tended to reduce the orientation error accident rate: e.g., the introduction to service of aircraft with automatic flight control systems and stability augmentation in the late 1970's; the installation of additional aircraft flight instruments such as radar altimeters in the early 1980's; the phasing out of predominantly single-pilot operations in the mid 1980's and subsequent introduction of two qualified pilot crews for most sorties in the late 1980's; and a reclassification of the accidents to exclude the lesser damaged airframe in 1991. A counterbalancing factor which has tended to increase the orientation error accident rate is the much greater use of night vision goggles since the mid 1980's. These devices, while enhancing external visual cues in the dark, do have considerable limitations in the perception of orientation. Notwithstanding these arguments, it is reasonable to assert that the SD demonstration sortie has contributed to reducing the accident rate in which SD is involved. This is most encouraging, especially as the military flying task is becoming more complex and now leaves little room for error from a physiological limitation such as SD.

Pilot Acceptance

The SD demonstration sortie has gained wide acceptance by Army pilots. It is extremely rare for aircrew not to misperceive their orientation during the maneuvers. In a survey conducted by Durnford (3), 79% of 338 aircrew considered the sortie to be beneficial, 19% were indifferent and only 1% considered it harmful! This finding confirms the subjective value of this additional aeromedical training.

Cost Benefit

From 1982 until September 1995, 1069 initial and 597 refresher students have flown on this sortie. On initial training, 180 Gazelle helicopter flight hours have been logged and 130 hours on refresher training. Using 1996 military operating costs, this represents a total cost over nearly 14 years of $252,000 U.S. This figure is less than one tenth of the replacement cost of the least expensive in-service British Army helicopter, and it would take many years of training at this cost to justify the purchase of a modern electro-mechanical demonstrator.

Conclusion

The SD demonstration sortie has been a most successful enhancement to the aeromedical training of British Army pilots. Both operational and cost benefits are apparent, and aircrew fully appreciate the value of the demonstration. There is, therefore, strong justification for the continuance of the sortie. Furthermore, similar instruction to that described in this paper could be readily adopted by other services. The author is presently conducting an acceptability assessment of this sortie in the U.S. Army and is most willing to communicate directly with interested parties.

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